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HUMBLE ADDRESS

To the Right Honourable the

L O R D S,

533.e. 23.

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And the rest of the Honourable

COMMISSIONERS,

Appointed by Act of Parliament to judge of all Performances Relating to the

LONGITUDE;

Wherein it is demonstrated from Mr. FLAMSTEED'S Observations, that by the late incomparable Sir ISAAC NEWTON'S Theory of the *Moon*, as it is now freed from some Errors of the Press, the LONGITUDE may be found by *Land* or *Sea*, either Night or Day, when the *Moon* is visible, and in proper Weather, within very few Miles of Certainty.

By R.^d Wright The Author of

VIATICUM NAUTARUM,

Now lying before the Honourable COMMISSIONERS.

LONDON: Printed for T. Page, W. and F. Mounr, at Tower hill; John Osborn and Thomas Longman in Pater-noster-row; and James Asfdell, Bookseller in Liverpool, 1728.

c. 2704.

HUMBLE ADDRESS

To the Right Honourable the

L O R D S

of the Honourable

COMMISSIONERS

Appointed by Act of Parliament to inquire into the

CONDUIT



Wherein is contained a full and complete account of the

By R. W. H. the Author of
NATURAL HISTORY
Now being the second Edition of the COMMISSIONERS

LONDON: Printed for T. D. N. and J. W. H. in Strand, 1798.

1798

...sole compared with Mr. Halley's Observations, whose Authority is
...to a few seconds of Motion, by which means the Motion may
...will be so nearly given, that the Longitude (if due Care be taken) may
...be found thereby, either directly, or with very few Miles of
...Error. Perhaps it will be look'd upon as an extraordinary Pretension, to
...attempt even the most minute Variation in any of Sir Isaac's Incom-
...putable Works. But there is no more to be said for this, than for
...would be a Recourse to his immortal Memory to let him for-
...a manifest Inconsistency, such as will appear to any sensible Mathematician.

May it please your

HONOURS



YOu will remember, that some time ago, there was presented to your Hands, a Treatise relating to the Longitude, Entituled *VIA TICUM NAUTICUM*; Wherein the Author encouraged, from the great Encouragements given of Sir Isaac Newton's Theory of the Moon, by Three very celebrated Mathematicians, undertakes thereby to discover the Longitude at Sea. He does not now

retract what he then advanced; but rather begs Leave to repeat to Your Honours, and to reinforce those Methods he then proposed of finding the Moon's Place by Observation. For altho' a certain Gentleman refused to present the aforesaid Book to Sir Isaac Newton, objecting there was nothing New in it (which it is strange he should tell without perusing it) yet, the Author knows they are all New to him, and thinks they will appear so to the Learned; since he is not an utter Stranger to the Books of *Astronomy* and *Navigation* now extant.

As to the Theory it self, the Testimony of those great Men, was of such Weight with him, that he thought he might safely depend thereon, so as to venture to make Tables agreeable thereto, which with great Pains he has done, and used the utmost Fidelity and Accuracy he possibly could in the making of them. But hearing since, the very sagacious and learned Dr. Halley, has by his own Observations found the Theory to be Erroneous sometimes, even to 5 or 6 Minutes of Motion, the Author thought he had a new Task imposed upon him, to examine the Theory himself; which accordingly he has done, and with all the Fidelity possi-

sible compared with Mr. Flamsteed's Observations, whose Authority he supposes will be undeniable. And he finds that the *Theory* being freed from some Errors of the Press, under which it certainly labours, (as printed in Dr. Gregory's *Astronomy*) and restored to its original Exactness, as it undoubtedly came from the Hands of its prodigiously ingenious Author, will reduce those 5 or 6, and perhaps sometimes more Minutes, to a few Seconds of Motion; by which Means the *Moon's Place* will be so nearly given, that the *Longitude* (if due Care be taken) may be found thereby, either precisely exact, or within very few Miles of Certainty.

Perhaps it will be look'd upon as an unpardonable Presumption, to attempt even the most minute Alteration in any of Sir Isaac's incomparable Works. This must certainly be allow'd, when they are proved to be His. But there is one main Error in the printed *Theory*, which would be a Reproach to his immortal Memory to let pass for His, even a manifest Inconsistency, such as will appear to any tolerable Mathematician to require an Alteration. And therefore an Alteration is made, and that a true one, as will be proved in it's proper Place. In the mean time Your Honours will be pleased to excuse the Repetition of some of those Methods of finding the *Moon's Place* by Observation, since probably the Book may be long since thrown aside, or your more necessary Thoughts may have thrust them out of your Memory. The first whereof, if perhaps not altogether so practicable at Sea, yet will certainly discover the *Longitude* of any Sea Port; by which the Sailor may examine his Charts, which 'tis to be feared, may in some Cases want to be rectified.

The Method is this; Suppose two *Fixed Stars* to have the same Right Ascension, or to come to the Meridian precisely at the same time, and let one of them be supposed in or near the Equinoctial, the other to have 60 or 70 Degrees of Declination; the greater the better, provided they be both betwixt the Zenith and the Horizon. Now it is undeniably certain, that those Stars will never be in the same Azimuth or Vertical Circle, but when they are upon the Meridian; for the higher Star will till then be always to the Eastward of the lower, and afterwards to the Westward; and in 2 or 3 Seconds a Variation may be perceived. When therefore these Stars are in one Azimuth, which may be easily known by a Plumb-Line, such as shall hereafter be described; one may exactly know the True or Apparent Time of the Night, by having their Right Ascension exactly known from the Tables, truly made from Mr. Flamsteed's Catalogue, and adjusted to the Year 1726, by his Rules

of Variation. Likewise, having their Declination given with the same Exactness, by taking the Meridian-Altitude of either Star; but rather the higher, as being free from the Errors of Refraction, (and Parallax, they have none unless an Annual) You may exactly find the Latitude by such a Telescopic Quadrant, as will be hereafter fully described. These, one would be inclined to think are no contemptible DATA. And if the Center of the Moon were supposed in the place of the higher Star, the Case would be the same; for her Motion Eastward in her own Orbit is as nothing, or bears no Proportion to the quickness of the change of the Azimuth. This it is desired may be particularly taken Notice of and remembered, for a further Use to be made of it.

All that hath been here said will appear plainly by Figure 1, where ZHNO represents the Meridian, HO the Horizon, Z the Zenith, N the Nadir, being the Pole of the Horizon, EQ the Equinoctial, P the North Pole thereof, S the South, (1) a Star in the Equinoctial, (2) a Star having 70 deg. of Declination, P sit S on Hour Circle or Meridian, at 4 Minutes distance from the other Meridian, making an Angle with it of a Degree or 60 Minutes in the Equinoctial, tho' here it be drawn bigger that it may be distinguished the better; ZsN and ZtN two Azimuth or Vertical Circles, ZE 10 degrees equal to HP the Latitude of the Place. Now here are given in the Spherical Triangle ZPs, (1st,) the Angle ZPs being 60 min. (2d,) the Side PZ Complement of the Latitude, being 80°, (3d,) the side Ps being 90°, it is required to find the Angle PZs, being the Azimuth from the North, and consequently its Supplement OZs will be its Azimuth from the South. Likewise in the Triangle ZPt there are given, the Angle ZPt the same as before 60°, and the side PZ as before 80°, the side Pt is 160°; to find the Angle PZt, whose Supplement to 180° the Angle OZt, is the Azimuth from the South. Working therefore by a known Problem in Spherical Trigonometry, the Angle OZs will be found to be 5° 45', and the Angle OZt 0° 24', the Difference 5° 21', is the Quantity of the Azimuth's Variation in 4 Minutes of Time. As therefore 5° 21' or 321', is to 4 Minutes or 240 Seconds; so is 31' 16" the mean Apparent Diameter of the Moon, (according to Sir Isaac's Theory) to 24 Seconds.

So that were the Moon in the Place of the higher Star, its whole Body would pass the other Star in 24 sec. of Time. And if the Moment were carefully observed, when the Western Limb of the Moon and the lower Star were exactly cover'd by the Line; as likewise the Eastern Limb, the middle Time between these would be the Moment, when the

the Moon's Center and the Star were exactly in the same Azimuth. For a small Thread would divide the Moon's Diameter into at least Twelve easily distinguishable Parts, and Two Seconds of Time may in this Case be pardonably called a Moment.

Your Honours may by this Time perceive the Design of this Method, which is briefly thus; the Sailor will find in the End of this Book a Catalogue of such Fixed Stars (put together by Pairs) as come to the Meridian nearly at the same Time, perhaps some at a Minutes Distance or little more; out of which he may pick out some, that may suit his Latitude. For Instance; if he be in the Latitude of 15, 20, 25, 30 deg. South, or the like, he may find that the *Virgin's Spike*, and the 2d in the *Great Bears Tail* marked (C) in *Bayer's Uranometria* will be proper for his Purpose, which Book by the way will instruct him to know all these Stars without a Master. Now the Difference of Right Ascension to these two Stars being but a Minutes or 8 Seconds of time; when he finds them both exactly united with his Line, 'tis but staying 8 Seconds; and *Virgin's Spike* will be upon the Meridian, whose Right Ascension given will tell him the True or Apparent time of the Night in the Place of Observation, and if at the same time he carefully takes the Altitude; her Declination will give him the exact Latitude. Here it may not be impertinent to observe, that if a Ship were in 15° of South Latitude, the Variation of the Azimuth of these two Stars, would after they were in the same Vertical, be 9° 48' 07" in 4 Minutes of Time.

So then, As 9° 48' 07" or 35287", to 4 Minutes or 240 Seconds; so is 31" 16" or 1876" the Moon's Diameter, to 13 Seconds; therefore the time of the Night might be known to a Second Minute, and if the Moon were in the Place of *Virgin's Spike*, it might be known to a Second of Time, when its Center and the (24) Star in the *Great Bears Tail* marked (C) in *Bayer's Uranometria* were in the same Azimuth or Vertical, for the whole Body of the Moon would in this Case pass that Star in 13 Seconds, as by Figure 2d, and the Operation will plainly appear.

The Operation.

In the Triangle PZ are given, PZ 105°, P 99° 43' 37", and the Angle Z P 1 deg. or 66 min. to find PZ's, measured by H a in the Horizon, the Azimuth from the North, in 4 Minutes of time, add *Flansted's Catalogue*, and suppose to the

PZ

(87)

PZ 105 : 00 : 06 Diff 05 : 16 : 33
 Ps 99 : 43 : 27 Diff 01 : 38 : 16

Sum 204 : 43 : 27 & the
 Sum 102 : 21 : 43 Ang. ZPs 30 : 00

As S. half Zcr. P Z and P s	102 21 43	Co. Ar.
To S. half Xcr.	2 38 16	0.610188
So Tc. half Z P s	0 30 00	8.662960
		12.059142

To Tang. half X of the other Angles 79 30 22 10.731190

Again,

As S. half Zcr. P Z and P s	102 21 43	0.669411
To Sc. half Xcr.	2 38 16	9.999539
So is Tc. half Z P s	0 30 00	12.059142

To Tang. half Z of the other Angles 89 53 33 12.728092

Half Z✓✓ 89 53 33

Half X✓✓ 79 30 22

The Difference 10 23 11 is the Angle P Z s, the Azi-
 muth of (s) from the North

Likewise in the Triangle P Z z.

		Co. Ar
As S. half Zcr. P Z and P z	69 18 52	0.028941
To S. half Xcr.	35 41 08	9.765919
So is Tc. half Z P z	00 30 00	12.059142

To Tang. half X of the other Angles 89 11 53 11.854002

Again,

As Sc. half Zcr. P Z and P z	69 18 52	0.451921
To Sc. half Xcr.	35 41 08	9.999679
So is Tc. half Z P z	00 30 00	12.059142

To T. half Z of the other Angles 89 46 57 12.420742

From

From 89 46 57
Take 89 11 53

From 19 33 11
Subtract 09 35 04

Remains 00 35 04
The Angle P Z z

Remains 09 48 07
The Difference of the Azimuths

So if he be in the like degrees of North Latitude, he will find that *Orion's Right Shoulder* (a) and the latter of the bright Stars in the *Dove* will be his best Directors; but the former coming to the Meridian 15' 33" or 61" of time before the other, he must stay a Minute and 1 Second after they are both cut by his Line, before he takes the Altitude of the former. If the higher Star's Ascension be more than the lower, he must take its Altitude a little before they are united, and the Difference of Ascensions reduced into time will tell him, that so much time is past that of the higher Star's Ascension.

The next thing requisite then, will be to describe the Plumb-line, which may be after this Form (*Fig. 3.*) the Side of which may be six Feet, and have Hooks to hang a *Lanthorn* on each Side, if there be Occasion, by the Darkness of the Night: For by this means the Line may be seen from Top to Bottom as plain as in the Day-time. The Observer sitting upon Deck is to hold the Sides in his Hands, and when the Ship rolls one way, he may command the Instrument the contrary; and so keep the Line to a perpendicular Direction, especially if an Assistant taking hold of the Lead in some gross Fluid, restore it to its Steadiness, which if it continue so for a Second or two will be sufficient. For the Observer sitting behind a very fine Thread, may see at once from the Zenith to the Horizon, and easily discern, when the two Stars are at the same time cover'd by the Line.

This Method surely is as practicable, as taking an Observation by the common Quadrant; and one would think when the Azimuth cannot be taken this way, neither can the Altitude by that, nor the Latitude found; but this must be left to Experience, which will best decide the Controversy.

To proceed therefore, and to shew the whole of this Design at once; when the Sailor finds he has a clear, calm, and Star-light Night, together with a Conveniency of the Moon, let him prepare for an Observation, and when he finds any two of these Stars near the same Azimuth, let him set up the Plumb-line with the Lanthorns, if he finds there will be Occasion, and when they are both exactly cut by his Line, let him take the Altitude of one of them; but rather the higher, as being less subject

to the Errors of Refraction ; and its Declination being known, will give him the true Latitude.

Having written down the Latitude, let him next carefully watch, when the Moon's Center and any known Star come into the same Vertical, and by taking the Altitude of the Star, let the Hour, Minute and Second be found, and at the same time let the Moon's Altitude be taken, by the help of an ingenious Assistant ; or these may be done before the Latitude is taken, if it be found necessary, always making due Allowance for the Ship's Way in the mean time, as every Artift's own Reason will direct him. When the Sailor by the means used, as is before directed, knows at what Apparent time, and in what Latitude the Moon was in the same Vertical with a Star, whose Right Ascension and Declination are likewise known, and also what was the Moon's Apparent Altitude at the same time ; by counterballancing the Moon's Parallax with the Refraction, so as will in its due Place be directed, he may find the Moon's true Altitude from the Center of the Earth ; there being no other Parallax to be here considered but that of Altitude, since every Vertical Circle passes through the Earth's Center. Knowing therefore what Minute of the Equinoctial was then upon the Meridian (by knowing the Hour of the Night) and the Stars Right Ascension, he knows the Angle at the Pole ; the complement also of the Latitude, and the Stars Declination being given, he may find the Star's Azimuth, and consequently the Moon's being the same, which being known, together with her true Altitude, he may find her Declination and Right Ascension, and by them her true Longitude and Latitude. And if after this he finds by Sir Isaac's Theory, at what Apparent time in the Meridian of *Greenwich* (for the Tables are made for that Meridian) the Moon will have that Longitude and Latitude, by reducing the Difference of those Apparent times into the Degrees and Minutes of the Equinoctial, he will have the true Difference of Longitude between the two Meridians, and consequently the true Longitude of the Place of Observation. *Q. E. D.*

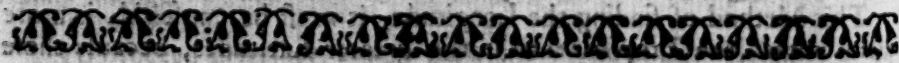
This Method of finding the Longitude, it must be confels'd, is more useful within the Tropicks than in the greater Latitudes, because those Stars which are far remov'd from the Equinoctial, will in this latter Case not be visible ; so that two Stars must here be made use of on either Side the Equinoctial, to have them far enough distant, and the change of Azimuth will not be so quick. In this Case the time must be carefully observed when they first come into one Azimuth, as also when they

go off, and the middle time must be taken for the true. So likewise, when the Moon is observed with a fixed Star.

Having proceeded thus far, the Sailor is to set to his Calculation, to find at what time, in the known Meridian, for which the *Tables* are made, namely, that of *Greenwich*, the Moon will have the Longitude and Latitude before found.

Supposing then his Reckoned Longitude to be true, let him reduce the Difference of Longitude into Hours, Minutes and Seconds of time, allowing for every Hour 15 Degrees, and proportionally for Minutes and Seconds. Having thus found what a Clock it is at *Greenwich*, according to his Reckoning, let him by the *Tables* of Equation of time, reduce that time to the mean or equal time, because the *Tables* are adapted to that, and let him try by Calculation, the Method whereof will be presently given, whether at that time the Moon will have the same Place in the *Ecliptick* as was found before: If it have, his Reckoning was kept true; otherwise it must be corrected by the *Table* of the Moon's horary Motion, thus; as the horary Motion is to 60': so is the Excess or Defect of the Moon's Place by Calculation, above or under that by Observation, to a fourth Number: this subtracted from, or added to the Apparent time at *Greenwich* before taken, gives a Number, which may be called (*b*), then, as 60' to 15°, so will the Number called (*b*) be to the true Difference of Longitude.

If this Method do not please, here follows a Second, which cannot be denied, if Mathematical Demonstration may be accepted, and if the Use of a most perfect Quadrant will be allowed. If not; but the Sailor will shut his Eyes against the Light at Noon Day, let him throw his Quadrant over Board, and cease to seek for the Latitude it self, and be content to grope about in that dark Labyrinth the Ocean; but never expect to arrive at the desired Port. But if the Latitude can be found by the Use of a Quadrant, so may the Longitude as truly by the same Instrument.



The Second Method.

LET therefore the Latitude be found (if the former Method will not be allowed) by waiting for a known Star's greatest Altitude, which

which the said Method will surely direct him when to expect; afterwards let the Height of that, or an other known Star be taken, either to the Eastward or Westward of the Meridian, and thereby let the Hour of the Night be found; and when the Altitude is taking by one Assistant, exactly at that time let the Moon's Altitude be carefully taken by another, and put down, that it be not forgotten; this Altitude must afterwards be corrected by the *Tables* of Parallax and Refraction. Having the true time of the Night, it may be known, what point of the Equinoctial was then on the Meridian, and by that the point of the Ecliptick culminating, as also the Declination of that point and the Angle, which the Ecliptick then makes with the Meridian, may all be easily found in the common Right-angled Spherical Triangle EAE , (Fig. 4.) comprehended between the Equinoctial, the Ecliptick, and the Meridian, the Obliquity of the Ecliptic being now agreed to be 23 deg. 19 min. Having proceeded thus far, the Moon's Place in her own Orbit, and consequently in the Ecliptick may be found, (1st,) by the Triangle EMF , in which let EF represent the distance of the point in the Ecliptick culminating from the nearest Node of the Moon, which will be found, and correctly equated by the Rules of the Theory, as will also the Angle EFM , the Inclination of the Orbit (at the time of Observation) to the Ecliptick; the Angle PEM is the Supplement of $AE\hat{E}$, namely, of the Angle which the Ecliptick at the time of Observation, makes with the Meridian; now from these it will be easy to find the Angle FME , comprehended between the Meridian and the Moon's Orbit, likewise the Side MF the distance between the culminating point of the Orbit and the Node, as also the side ME , which added to, or subtracted from the culminating point of the Ecliptick (according as the Moon's Latitude is North or South) and that Sum or Difference added to the Height of the Equator above the Horizon, or to the Complement of the Latitude, will give the Height of the point in the Moon's Orbit then upon the Meridian. (2dly) in the Triangle GMA there will be given MZ the distance in the Meridian between the point M and the Zenith, namely HZ or $90^\circ - H\hat{A}E + AE\hat{E} + E\hat{M}$, likewise the Angle ZMG the Supplement of EMF to 180 deg. or a Semicircle, and also the side GZ the Complement of GR , or of the Moon's corrected and true Altitude; which being given, the side MG may be likewise found, which subtracted from MF leaves the Moon's Place in her Orbit, which will easily be reduced by the *Tables* to the Ecliptick, and her Place found by Observation, which is all that was here required.

Or it may be done by the Triangle GCF , Right-angled at C , for GCF being a Right-angle, and CFG before found by the Table of the Equation of the Nodes, and $GF = MF - MG$; the Moon's Latitude will be GC , and the side $CF = EF - EC$ will shew the Longitude, or her true Place in the Ecliptic, and by the said Triangle may both be found, *Q. E. D.*

Yet farther, some Persons may perhaps disapprove of these Methods of taking Observations in the Night: To remove therefore such an Objection, and to satisfy as much as may be, the different Humours and Opinions of various Minds, (though in a Matter of such Difficulty as the Longitude is, they cannot reasonably expect to have all their nice Scruples entirely removed.) Here is added a third way of finding the Moon's true place in the Ecliptick, and consequently the Longitude (still by the help of Sir Isaac Newton's Theory) in the Day time, and so without the Assistance of the Stars, by the common Instruments used at Sea, namely a Quadrant and an Azimuth Compass. Thus,

The Third Method.

LET the Latitude be found after the usual Manner, by taking the Sun's greatest Altitude, and by his Declination, and shortly after by taking another Altitude, at the same time observing the Magnetical Azimuth by the Azimuth Compass; by these three, viz. the Latitude, Declination and Altitude of the Sun's Center, (making Allowance for Refraction) the true Azimuth may be found: And by that and the Magnetical Azimuth, may also be found the Variation of the Compass in the Place of Observation. This Variation will suffer no Alteration worthy of Regard in a small Distance of Time or Place; therefore exactly at the time of Sun-setting, viz. when the lower Limb of the Sun is above the Horizon about 16 min. or half its Diameter, and may better be known at Sea than Land, the Center being then by Reason of Refraction upon the sensible Horizon, which may safely enough be taken for the Rational, since the Earth's Semidiameter bears little or no Proportion to the Sun's Distance. If at that Moment the Magnetical Amplitude be very carefully observed, by adding to it, or subtracting from it, the Variation of the Compass found before, the true Amplitude or the Distance in the Horizon, betwixt the Sun's Azi-

moth and the West Point will be had: Then in the Rectangle Triangle $\odot P O$, in *Figure* the 4th, right Angled at O , the Complement of the Amplitude $\odot O$ being given, and the Complement of the Declination $\odot P$, it will be easy to find the side $P O$ the true Latitude of the Place, and also the Angle $\odot P O$, the Time to Midnight, and consequently the true time of the Day; always observing to allow for every Hour 15 deg. of the Equinoctial, and moreover such a Part thereof as answers to the Variation of the Sun's Place in the mean Time, and proportionally for Minutes and Seconds. Having the true time of the Day, it may be exactly known, what point of the Equinoctial was upon the Meridian at the time of Sun-setting, and by that Means may be found what part of the Ecliptick was also on the Meridian. Likewise the Arch of the Meridian intercepted between the Equator and the Ecliptick, as also the Angle between the Ecliptick and the Meridian. And if the Altitude of the Moon's Center were also carefully and exactly taken at the same Instant of the Sun's setting by one Assistant, when the Magnetical Azimuth was observed by another, and that Altitude corrected by the Tables of Parallax and Refraction; by proceeding as in Page 11th, the true Place of the Moon in the Ecliptick, both as to Latitude and Longitude, may be exactly demonstrated, which was the thing before proposed. The like may be done at Sun-rising, if the Moon be then past the Full; as in the other Case of Sun-setting, it was supposed to be before it.

If this Method still admit of an Objection, as suppose that the time of Sun Rising or Setting cannot be exactly enough determined; let this further way decide the Controversy, and pass all Exception shew, how to find the Moon's Place in the Ecliptick, and consequently (by Sir Isaac's Theory and the Tables calculated according to it) to find the Longitude of the Place of Observation at any Time, or in any Place, when or where the Sun and Moon are both visible.



The Fourth Method

HAVING before found the Variation of the Compass, as was just before directed, let the Sun's Altitude and Azimuth, and likewise the Altitude of the Moon's Center be taken at one Instant with the best Instruments, that are already, or may be hereafter contrived; and with

all

all the Care that can possibly be applied. Having the Variation of the Compass given, and the Sun's Magnetical Azimuth observed, by adding or subtracting the former to, or from the latter, the Sun's true Azimuth may be found; by which together with his Altitude (corrected by the Table of Refraction) and present Declination, the Latitude of the Place, and the Hour of the Day may be exactly found, by which two and the true Altitude of the Moon, her Place in the Ecliptick (by Fig. the 4th, and the Rules foregoing) may be likewise found; which is all that was desired, or can by any reasonable and unprejudiced Person be required.

The Fifth Method.

THE Fifth and last Method (which, if Night Observations may be allowed is none of the worst, especially for great Ships, where a sufficient Number of Hands are) is this which follows, (See Fig. 5.) in which let P represent the Pole of the World, Z the Zenith of the Place, PA the Complement of the Star A's Declination, PB the Complement of B's, the Angle APB the Difference of their Right Ascensions, and AB their Distance. Some time before the Observation be taken, let two known fixed Stars be chosen on each side of the Meridian, whose Right Ascensions and Declinations may be found in my Tables calculated from Mr. Flamsteed's Catalogue, for the Year 1726, by his Rules of Variation; then in the Triangle APB, AP, and BP and APB being given, the side AB may be found, and likewise the Angles BAP and ABP.

Having proceeded thus far, let the Altitude of these Stars and of the Moon be taken exactly all at once, by three careful Observers, which (having made a due Preparation before hand, so as will shortly be shewn) may be done in two or three Seconds of Time, and the Business is over for the present. The Instruments may be laid aside, and the Calculations made any time after at Leisure; only it will be proper at this time to heave out the Log, and that a careful Estimate be taken of the Travels, (according to the usual Rules of Art) till another Observation: In the mean time let the Latitude and Longitude the Ship was in at the time of Observation be found thus; in the Triangle AZB, the three Sides are given, viz. AZ the Complement of the

Star

Star A's Altitude, and BZ the Complement of B's, and the Distance AB found before, it will be easy to find the Angles BAZ and ABZ, but either will be sufficient, for $BAP - BAZ = ZAP$, or $ABP - ABZ = ZBP$; then PA and ZA, and ZAP being given, or PB and ZB and ZBP being given, PZ may be found, being the Complement of the Latitude, and by the Latitude of the Place, Altitude, Right Ascension and Declination of either Star, may be found the exact time of the Night, and likewise according to the foregoing Rules, the true Place of the Moon in her Orbit (supposing the Eye in the Earth's Center) by the Tables of Parallax and Refraction. Whilst one Man is performing this, another may be calculating what a Clock it was at Greenwich, at the very same absolute Time, and so this difficult Problem may be truly solved.

By this last Method alone, (much more by altogether) Observations may be taken almost at Pleasure, and the Longitude as well as Latitude found, and the Reckoning corrected as to both, more exactly and more frequently, than even the Latitude it self, by the Methods hitherto practiced.

Having thus proposed to *Your Honours* five new Methods of finding the Moon's Place by Observation, all which are certainly true in *Theory*, and may be easily and very often practiced by the Use of a Quadrant now to be described; not excepting the first, which will be found upon Trial fully as practicable as by the common Quadrant; I proceed now to shew how these Methods may be reduced to Practice.

The best Instrument for this Purpose yet invented, is the *Fluid Quadrant*. (Fig. 6.) of the ingenious Capt. Row, which (by his Leave) with some Alteration, may be rendered Thirty times more exact than that of Capt. Davis, even to 3 or 4 Seconds, and with a great deal more Speed and Satisfaction; since by that both the Object (or the Shadow) and the Horizon must be observed at the same Instant, and so much time is taken up in removing the Vane up and down till it be exactly adjusted, that in the mean while the proper time will be lapsed, and the Object moved from the Meridian; whereas this Quadrant is attended with no such Inconvenience: For the Sight of an Object may speedily be gotten by a *Tube* of not above 6 Inches long, which is to take in exactly the whole Body of the Sun or Moon (when their Apparent Diameters are the greatest) and no more, by which means, when the Observer has their full Body in View, he is sure the Center of the *Tube* is directed to their Center, and so with cross Hairs to that of a Star, so that if he can but see their Bodies for three or four Seconds

of time, he may be assured of a most exact Observation to 3 or 4 Seconds of Altitude; for in so short a Time may an Assistant remove a Sliding Bridge to the End of the Bubble. In order to explain the Design of this Quadrant, suppose there were a hollow Glass Ring of 40 Yards Diameter, half an Inch thick, and of a true circular Curve throughout, and equally wide, filled with Water or Spirits of Wine, all but till it left a Bubble of Air, about an Inch and a half or two Inches long; this Bubble of Air as the Ring were turned about, would always be uppermost; or in other Words, if a strait Line parallel to the Horizon were applied to the Ring it would always touch it in the middle of the Bubble. And if the Ring were moved, till the aforesaid Tangent Line should make an Angle of one Degree with the Horizon, or be elevated one Degree above it, the Bubble would be removed one Degree, or the 360th part of the whole Ring more forward in the *Tube*, and would move equally if the *Tube* were truly made: now the Sine of one Deg. to this Radius of 20 Yards, will be found to be one Foot and 571 thousandth parts of an Inch, and the Versed-line one tenth of an Inch. If one Degree of this Ring were laid in a Groove on the Edge of a truly circular piece of Wood of the same Radius of 20 Yards, and about 2 Inches broad, and the broad Side diagonally divided into Minutes and Seconds, as this piece of Wood should be advanced one Degree, the Bubble would be moved from one End to the other, and in its Motion the End of it would tell the Minutes and Seconds of that Advancement; especially, if a Sliding Bridge moving readily, were set to the precise End of it, and there fastened with a Screw.

To proceed farther; a Quadrant must be made of the Radius of 12.571 Inches, or some little more, for the one Degree Arch should be an Inch or two longer at both Ends than 12.571. This Quadrant may be divided only into single Degrees, beginning at the Right-hand End of the Arch, when the Center is towards you, at 3 quarters of an Inch from the Beginning of the Divisions on the other one Degree Arch, (I now suppose the Bubble $1\frac{1}{2}$ Inch long.) Two little pieces of Brass may be affixed to the Arch on either Side, to project so much over the Glass *Tube*, as to allow room for two Holes, to receive a slender Screw fastened in the Center of the Quadrant, upon which screw when these two pieces are put, another little female Screw will fasten the one Degree Arch to the Quadrant, and if at the other End it be fastened to the Limb of the Quadrant by a Clasp and Screw, so as it may by taking those off be moved along the Edge of the Quadrant

at pleasure, and so fastened again, it will be ready for Use, which will be thus; some small Time before the Altitude of any Object is to be taken, let the Observer view the same through the Tube, and at the same Time let an ingenious faithful Assistant observe where the Bubble is in the Glass; if it be at the farther End from the Eye, let him loose the Screw upon the Center, and quite take off the other at the Limb, and move down the one Degree Arch towards 90 degrees on the Quadrant, till the Bubble begin to move, and continue to move the Arch to the next degree of the Quadrant, and at that even Degree of the Quadrant fasten it by the Screws: For Example, suppose the Sun or Moon were 40 deg. 30 min. high, and the Arch were fastened at 30 deg. of the Quadrant, if the Observer directed the Tube to their Center, the Assistant would find the Bubble at the farther End of the Glass, let him loose the Screws and bring down the Arch, till the Bubble begin to move, which will be at 39 deg. 30 min. let him farther bring down the Arch to 40 deg. and there fasten it; for if the Observer look again, and hold his Instrument as steady as he can, the End of the Bubble will rest exactly at 30 Minutes, at which the Assistant may in an Instant lay his Thumb, then move the Bridge to it and fasten it, and the Observation is over; for he may count the Divisions afterwards at his Leisure. Being thus far prepared, the Quadrant may be hung up, and at any Time may be taken down again, and in three or four Seconds an Observation truly taken, till the Object be 41 deg. high; for then the Bubble will have sought the End of the Divisions, namely, to 60 Minutes, then 'tis but removing the Arch to 41 deg. of the Quadrant, and there fastening it, which will reduce the Bubble to the Beginning of the Divisions on the Arch, and need not be altered till the Object be 42 deg. high, and so on.

Now by the Laws of Hydrostaticks, when the Tube is directed steadily to the Center of the Object, the Bubble must necessarily rest in the true Place of the Glass, still supposing it a true circular Curve, and truly Cylindrical, especially if this one thing be further observed, viz. suppose the Center of the Object exactly upon the Horizon, if the Arch be set to the Beginning of the Divisions on the Quadrant, the middle of the Bubble will be at the Center, and the End at the Beginning of the Divisions on the Arch; but then this being a Curve will fall off a little at the Distance of 12,571, from the Beginning of the Divisions nearest to 90 deg. therefore a little piece of Brass must be affixed to the Arch in that Place, that may reach just to the Beginning of the Divisions, or that may meet the Line, which touches the middle of the Bubble, if

continued. This piece of Brass being thus affixed, suppose the Center of the Object exactly 40 degrees high; if the End of this Piece be set to 40 degrees on the Quadrant, and there fastened, when the Tube is directed to the said Center, the End of the Bubble will be exactly at the Beginning of the Divisions on the Arch (i. e.) at (0). Still supposing the Bubble an Inch and a-half long, which will be difficult to keep to, by Reason the Liquid will be wasting, and if more be infused, it will probably be too much or too little; and if it be, it is not material; for the Length of the Bubble ought always to be measured some Time before the Observation, and Allowance made. For Example, Suppose instead of $1\frac{1}{2}$ it be 2 Inches long, then instead of $\frac{3}{4}$ quarter there will be 1 Inch from the Center. So that it will reach $\frac{1}{4}$ quarter of an Inch too far; and so much must all the Length be deducted from the Number which the End of the Bubble points at. A Tube of 6 Inches will be long enough; since there is no need of magnifying; and the shorter it is, the sooner will the Sight of an Object be gotten. If the further End of the Tube have an Aperture of 6 hundredth parts of an Inch, with a plain Glass smoked, it will just take in the Body of the Sun or Moon; but for a Star there must be two Convex Glasses and cross Hairs; the End of the Tube next the Eye should in the former Case be pierced with the point of a Pin or Needle. Now if the learned Dr. Halley found it practicable (as in his Appendix to the Second Edition of Mr. Street's *Astronomia Carolina*, he says he did) to observe the Occultation of a Fixed Star, with a Tube of five or six Foot, at a necessary Instant, surely it cannot be thought impracticable to observe the Sun, or Moon, or Star, with a Tube of 6 Inches; whereby the Sight of them may be sooner obtained, (especially, considering how difficult it must be to hold a Tube of that Length sufficiently steady) and that not at a necessary Instant, but at Discretion.

By what has been hitherto advanced, it will appear very plain to *Your Honours*, that the Moon's Place in her Orbit may be found to sufficient Exactness, as often as will be necessary, by some one or other of the aforesaid Methods. There will be no Occasion of reducing that Place to the Ecliptick, since (because the Moon is always in Motion, and consequently never above a Moment of Time in the same Place) it can be found to a few Seconds of Motion, at what Time in the Meridian of *Greenwich* the Moon will be in the same Place of her Orbit, supposing the Eye in both Meridians to be in the Center of the Earth (which by truly counterbalancing the Angles of Parallax and Refraction, will be in effect done) if the Difference of these two re-

lative

lative Times (for it is the same Absolute Time) be reduced into the Degrees and Minutes, &c. of the Equator, no Person that knows what is meant by the Longitude, can deny, but it may by this Means be found to the Exactness required by Act of Parliament, and a great deal less. It remains therefore to demonstrate from Mr. Flamsteed's Observations in a sufficient Variety of Cases, that by Sir Isaac Newton's Theory of the Moon, as it ought to be, and is here actually freed from the Errors of the Press, the Moon's Place in her Orbit may at any Time be found so exact by Calculation from Tables truly agreeable to that Theory, as it is here corrected (which, if this Performance meet with Encouragement, will soon be published), that the Longitude may thereby be discovered to a few Miles. Therefore I come now to shew where the Theory (as printed in Dr. Gregory's *Astronomy*, and in Mr. Whiston's *Astronomical Lectures Translated*) is, and must necessarily be erroneous, and that it is the true and only Reason, why Dr. Halley finds it sometimes to vary five or six Minutes of Motion from Truth, and also to make it appear, how it may, and ought to be altered to its original Exactness, so as to reduce those five or six Minutes to a few Seconds.

In the first place we find it printed in Dr. Gregory's *Astronomy* (Page 332) that in the Year 1680, on the last Day of December at Noon, the Mean Motion of the Moon was $68^{\circ} 01' 35'' 45'' 9$ and that 20 Years after, viz. in 1700, at the same Time of the last of December the Mean Motion of the Moon was $108^{\circ} 15' 19' 50''$; now here is a manifest Error of the Press; for if the former Mean Motion be true, the latter must be false, and if the latter be true, the Error lies in the former; as will plainly appear from what immediately follows, viz. that in 20 Julian Years or 7305 Days, the Mean Motion of the Moon is 447 Revolutions, $48^{\circ} 13' 34'' 05''$; this Motion of 20 Years added to $68^{\circ} 01' 35'' 45''$, will make $108^{\circ} 15' 09' 50''$, as it certainly ought to be printed, instead of $108^{\circ} 15' 19' 50''$; otherwise, if this last be true, the former instead of $68^{\circ} 01' 35'' 45''$, should be $68^{\circ} 01' 45'' 45''$, as it is printed in the Tables annexed to Mr. Whiston's *Astronomical Lectures*, and as I after him (not having then compared the Theory with the Observations) have put it in my *Vaticum Nauticum*; but I find this last to be wrong, and that it makes all the Calculations intolerably wide; and therefore I must humbly beg of Your Honours, when you order these following Calculations to be examined, that you will be pleased before-hand, to order the aforesaid Book to be corrected in

the foregoing Particulars, namely, that for the Year 1681, the Radical Number may be refer'd to 6S. 01° 33' 45", and for the Year 1701, to 10 S. 15° 09' 50" since the Calculations are made from these last Numbers, which are evidently the true.

This first Error of the Press being thus truly corrected, I proceed to the next main Mistake thereof, which upon due Examination will appear a manifest Inconsistency, and such as could never proceed from the Hands of the wonderful Author; therefore to do Justice to his illustrious Character (which had it been attempted by an abler Hand, would in all Probability have been much more regarded) and in order to set these things in their true Light, the Figure in Dr. Gregory's *Astronomy*, (Page 334.) is to be considered, see *Figure* the 7th, where if the Mean Distance of the Moon from the Earth be supposed 1000000, the greatest Excentricity of the Moon's Orbit represented by TB, is 66782, and the least Excentricity by TA, is 43319 of such Parts, as the Mean Distance contains a Million. Now if BTE represent the Annual Argument of the Sun, BCF the double thereof; TE the Excentricity and BTF the Equation of the Apogee required to be found. The Rule is this, being the 3d Axiom in *Plane Trigonometry*, viz. As the Sum of the Sides TC and CF=TB, is to their Difference, equal to TA, or as the greatest Excentricity 66782, is to the least 43319; so is the Tangent of half the Sum of the Angles CTF and CFT, or so is the Tangent of half the Angle BCF, or thirdly, so is the Tangent of the Annual Argument, to the Tangent of half the Difference of the Angles CTF and CFT, which half Difference subtracted from the half Sum, or (which is all one) from the Annual Argument, will give the lesser Angle CTE which is required; being the Equation of the Apogee. To find therefore the greatest Equation thereof, which will be found to be, when the Annual Argument is 51 degrees, work thus; As TB 66782, is to TA 43319, so is the Tangent of 51°, to the Tangent of 38° 41' 45", which subtracted from 51 deg. there will remain 12° 18' 15".

Co. Ar.
As 66° 28' 22" ————— 3.475341
Ta 43° 30' 49" ————— 4.6326678
So is T. of 51° ————— 10.091631
To T. of 38° 41' 45" ————— 7.903651

To T. of 38° 41' 45" ————— 9.00365

So then if those Excentricities be true, the greatest Equation of the Apogee must of Necessity (according to Sir Isaac's Theory) be $12^{\circ} 18' 15''$, whereas it is there printed $12^{\circ} 15' 04''$, and if this last $12^{\circ} 15' 04''$ be the true greatest Equation of the Apogee, (as upon farther Examination it will be found to be) then the Excentricities must be wrong. This is that manifest Inconsistency before taken Notice of, which cannot be imputed to the great Sir Isaac Newton, and which is the only Reason, why this Theory is found Erroneous to five or six Minutes, and some times more, and cannot possibly be otherwise; for these Excentricities being too great, it always appears, that if the fourth Equation of the Moon be made by Addition, the Calculation is too much, and exceeds the Observation, by adding too great a Prosthaphæresis to the third Equation; but if it be made by Subtraction, the Calculation will be always too little for the Observation. And this so much the more, as the Excentricity is greater at the Time of Observation, and the Moon's Mean Anomaly nearer to the Quarters, viz. to 3 and 9 Signs, when the Prosthaphæreses are the greatest.

I make no doubt, Your Honours will look upon this to be true Reasoning. Since therefore it is apparent to every one, that the Theory is false printed, and for that Reason ought if possible, to be corrected; and since it will appear by all the Calculations, that this Error is solely to be laid upon the Excentricities being too great, and that if they be retained, it cannot be otherwise; surely a Pardon (if it ought to be so called) will be easily granted for making an Alteration, more especially, if by such an Alteration (and by no other) all the Difficulties may be removed, and the Moon's Place in all Cases found to a sufficient Exactness; which in a due Order of proceeding is the next and main thing to be fully proved and demonstrated.

The following Observations all taken out of the Second Volume of that famous Astronomer Mr. Flamsteed's *Historia Cælestis Britannica* (though many more might have been produced to confirm the same thing, yet) may be thought sufficient, by Reason they are so pick'd out and designedly chosen to serve all the various nice Cases that can happen, (namely of the Earth's Distance from the Sun, of the Sun's Distance from the Moon's Apogee, of the Moon's Distance from the Sun, and from her Apogee, of the Equations of the Earth's Orbit, and of the Moon's Excentricities) that no Observation can be taken but will agree with, or come very near to some or other of them, insomuch that if these Observations be true, for which we must depend upon the Testimony of the Observer, both as to the Moon's Meridian Altitude and

and the true or apparent Time of the Night, and if the Calculations be exactly agreeable to the *Theory*, as here altered from the Print, it farther, the Moon's Motion be not a Motion at Random, but (though subject to various Anomalies, yet) constant and regular (as we may say) in its Irregularities; then the Consequence will be, that by any Observation truly taken at Sea, by a sufficient Instrument, such as is before at large described, and by an accurate Calculation made from the Tables, which (if this Scheme be accepted) will soon be published, together with all other Tables serviceable in the Calculation of Eclipses of the Luminaries; by these two, I say, the Longitude may be found to a sufficient Exactness. And a farther Consequence will be, that (supposing the Sun and Moon, or rather, if you please, the Earth and Moon be providentially determined as to their Motions, so that they are the same, and will so continue, as they formerly have been; which no one sure will deny, then) when any Observations are taken, and the Calculations truly and exactly made, do not agree very near therewith, those must of Necessity be false Observations. This is an undeniable Consequence from the former Suppositions. So that in order to render this Scheme impracticable, false or invalid, either the following Observations must be proved false, or the Calculations wrong, for no one surely, will be so daring or silly, as to dispute against the settled Laws of Nature. As to the Second, I humbly submit them to the most strict Scrutiny, and am perswaded, I may say without Vanity, that (abating the Errors of the Press,) they are all truly done to a Second, such Accuracy and Fairfulness has been used through the Whole.

To make this the better appear, I think it not improper, as I proceed to shew the Manner of my Calculations, (for in order to serve the Publick, I shall not grudge the Discovery of any *Arcanum* relating to this Subject) that so, if it appear to *Your Honours*, I have taken any false Steps, a speedy Answer (which in that Case I humbly request *You* will order to be drawn up) may prevent any farther Application. Or, if no Answer be given in due Time, I may be justly encouraged. For with all due submission to *Your Honours* better Judgment, I hope I may be permitted to say without boasting, that I cannot think this so petty, trivial, jejune, and insignificant a Performance, that it ought to be thrown a-side unregarded, and buried in Silence, without taking Notice of; but rather (if the Universal Benefit of Mankind is to be regarded) I hope it may deserve either a fair Answer, or a due Encouragement. *Your Honours* will be pleased to excuse this, (I should hope) not ill ground-

grounded Assurance; but lest I should seem to prescribe to *Your Honours* much ripet Judgment, I pass on to shew the Method I have proceeded by in the following Calculations: And to be as brief as possible, shall explain only one, for all the rest are managed after the same Mannner. I shall pitch upon the 4th Observation, because the Calculation agrees exactly with it.

In the 350th Page of the aforesaid Book, we find that in the Year 1698 being the 2^d after Leap-year, on *Thursday, June 16^d. 14^h. 46' 33"* Apparent Time in the Meridian of *Greenwich*. the Latitude whereof, according to Mr. *Flamsteed* is $51^{\circ} 28' 30''$ the Moon's Center past the Meridian, the higher Limb of it being distant then from the Vertex $63^{\circ} 46' 40''$, by the Diagonal Lines on the Instrument, but more correctly (by 1446 Revolutions of the Screw) 20 Seconds more, viz. $63^{\circ} 47' 00''$, from which subtracting $7' 30''$ for the Quantity, that the Meridian Wall had shrunk since it was first erected, which was his Way of computing, as will appear from Page the 117th of his *Prolegomena*, the Remainder will be $63^{\circ} 39' 30''$, for the Apparent Vertical Distance of the Moon's higher Limb. By the way it may be noted, that there is a Mistake of the Press, in the just now quoted Page, viz. in Line the 5th, for whereas it is printed Error Div. + $0^{\circ} 0' 20''$, it ought to be $0^{\circ} 0' 28''$, as will appear from the 9th Page of the Appendix to the Second Volume, where 38 hundredth Parts of one Revolution of the Screw, constantly answer to 1 Min. of Altitude. Now if recourse be had to the 85th Page of Vol. 2^d. it will be found, that on the 12th of *December, 1690.* at Noon, the Sun's lower Limb was distant from the Vertex $75^{\circ} 11' 30''$, and 1704,69 Revolutions of the Screw. Since therefore in the Appendix 1704 Rev. 51 C. P. answer to $75^{\circ} 11'$ by the Rule of Proportion, As 38 Cent. : $60''$: : 18 C. : $28''$, therefore $28''$ ought to be added to $75^{\circ} 11'$, and the Distance ought to be $75^{\circ} 11' 28''$, so that either $28''$ ought to be added to $75^{\circ} 11' 00''$, or from $75^{\circ} 11' 30''$, there should be $2''$ subtracted. In this Place I cannot forbear to remark, that it is a Thing much to be lamented by all lovers of *Astronomy*, that this otherwise never to be sufficiently valued Book, is so monstrously false printed. But to return from this Digression; having premised thus much, I shall now shew in one Instance the Method of my Calculation fully in all its Parts, by which the rest may be fairly examined.

From

From my *TABLES* in the other Book may be had these Numbers.

	Sun's Mean Mo.	Sun's Apogee.			
	S. ° ' "	S. ° ' "		S. ° ' "	S. ° ' "
A. D. 1681	09.20.34.46	03.07.23.30	Sun's Mean	3.05.40.15	3.05.40.15
Years 17	11.29.52.54	17.51	Motion	3.05.40.15	3.07.41.50
June	04.28.49.58	26	Eq. Earth's		
Days 16	15.46.13	3	Center +	04.00	11.27.58.25
Hours 14	34.30		Sun's Place	3.05.44.15	Mean Anomaly.
Minutes 46	1.53	03.07.41.50	Par. Pro. +	06	
Seconds 33	1		Sun's Place		Eq. 1 + 0.16
			Correct.	3.05.44.21	Eq. 2 + 2.04
	03.05.40.15				Eq. time + 2.20
					☉'s hor. } 2.13
					Motion } + 0.06
					Parts } + 0.06
					Proport. }

Thus the Sun's true Place, the Apparent Time being reduced to the Mean, was then 3 S. 05° 44' 21". The Moon's Place for the Mean Time is now to be found,

The Moon's Place is sought for the Mean Time, June the Sixteenth, 14 Hours, 48 Minutes, and 53 Seconds, A. D. 1698. in the Meridian of Greenwich:

A. D.	Moon's Mean Motion.	Motion of the Apogee.	Motion of the Node Retro.
	S. ° ' "	S. ° ' "	S. ° ' "
1681	06 01 35 45	08 04 28 05	05 24 14 35
Years 17.	03 02 14 19	11 01 44 03	10 28 47 56
June.	06 09 38 08	16 49 21	07 59 46
Days 16.	07 00 49 20	01 46 57	50 50
Hours 14.	07 41 10	03 54	01 51
Minutes 48.	26 21	13	06
Seconds 53.	29	00	11 07 40 39
	10 22 25 32	07 24 52 33	06 16 34 06

Having

Having thus found the Moon's Mean Motion, the Place of the Moon's Apogee, and of the Ascending Node, the next Thing in order according to Sir Isaac's Rules will be to find their first Equations, thus, As $1^{\circ} 56' 20''$ is to $4'$ the Equation of the Earth's Orbit, so is $11' 49''$ to $24''$, and so is $20'$ to $41''$, and so is $9' 30''$ to $20''$; and because the Eq. Orbit was $+$, the second must be $-$, the third $+$, and the fourth $-$; but had the Equation of the Orbit been $-$, then the other three must have been contrary to what they are. To find the Moon's second Equation, having first subtracted the Place of the Moon's Apogee first equated from the true Place of the Sun, say thus; As Radius is to the Sine of the double Distance of the Sun from the next Syzygia or Quadrature (by Syzygia is meant either the Conjunction with, or Opposition to that Place of the Apogee) so is the natural Number answering to the Logarithm in the last little Table, found by the Sun's Mean Anomaly, to the natural Number required. This must be added, if the Sun be moving to the Syzygia; but if from it, to be subtracted. In this Case the Number $3' 32''$ being subtracted from the first Equation of the Moon, leaves $10^{\circ} 22' 31' 36''$ for the Moon's second Equation; then to find the Moon's third Equation, first subtract the Place of the Node the first time equated, from the true Place of the Sun, and say; As Radius is to the Sine of the Sun's double Distance from the next Syzygia or Quadrature, so is 47 sec. to the Number required; which is here 17 sec. this (contrary to what was in the foregoing Article) must be $-$ or subtracted, when the Sun moves to the Syzygia, and when from it, to be $+$ or added, the Moon's Place the third time equated will be $10^{\circ} 22' 21' 53''$.

Thus far the Process is the same, whatever be the Excentricities; but if we take the printed Excentricities, they being too great, and the Prosthaphæresis to be $-$ negative or subtracted, because the Moon's Mean Anomaly is less than six Signs, the fourth Equation, and so the whole Calculation will be $6' 10''$ too little for the Observation, as by Computation may be found, whereas by these Excentricities, viz 65633, whereof the Logarithm is 4.817122 for the greatest, and 4.2655, the Logarithm 4.619965 for the least, they will both exactly agree; and these will also produce the true greatest Equation of the Apogee 12 deg. 15 min. 04 sec. thus by Axiom the 3d of Plane Trigonometry, as in Page the 20th. —

D

As

As 65633	Co. Ar.
To 42655	Log. 5.181878
So is the Tangent of 51°	4.619965
	10.091631
To the Tang. of 38° 44' 36"	9.904474
This subtracted from 51 00 00	
Leaves	12 15 04 the Equa. req.

The next thing to be done, is to find the second Equation of the Moon's Apogee, and the present Excentricity, thus by *Figure* the 6th; As $TC + FC = TB$ is to $TC - FC = TA$, or as is the greatest Excentricity 65633 to the least 42655, :: so is the Tangent of half the Sum of the Angles CTF and CFT, or so is the Tangent of half the Angle BCF, or 3dly, so is the Tangent of the Annual Argument, to the Tangent of half the Difference of the Angles CTF and CFT, which half Difference subtracted from the half Sum, or (which is all one) from the Annual Argument, will give the lesser Angle CTF, which is required, being the Equation of the Apogee. Therefore, having subtracted the Moon's Apogee the first time equated from the true Place of the Sun, the Remainder will be the Annual Argument, or the Sun's Distance from the Apogee, being half the Angle BCF. Thus from 3 S. 05° 44' 21" subtract 7 S. 24° 53' 14", the Remainder 7 S. 10° 51' 07", is the Annual Argument; then as 65633 is to 42655 :: so is the Tangent of 7 S. 10° 51' 07", or of 1 S. 10° 51' 07", to the Tangent of 29° 20' 10" this subtracted from 1 S. 10° 51' 07", leaves 11 30' 57", for the second Equation of the Apogee, which if the Annual Argument be under 3 Signs or above 6, as here, and under 9, must be added, otherwise subtracted.

The Operation.

As 65633	Co. Ar.
To 42655	Log. 5.181878
So is the Tangent of 40° 51' 07"	4.619965
	9.936896
To the Tangent of 29.20.10	9.749739

This 11 deg. 30 min. 57 sec. added to 7 S. 24 deg. 53 min. 14 sec. gives 08 S. 06 deg. 24 min. 11 sec. for the Place of the Apogee a 2d time equated.

To

To find the Excentricity of the Moon's Orbit at the time of Observation; As the Sine of the Angle CTF (in Figure the 6th,) last found, viz. $11^{\circ} 30' 57''$, is to the Side CF equal to the half of $TB - TA$ equal to 11489 : : so is the Sine of TCF equal to the Sine of BCF, equal to twice the Annual Argument, equal to the Sine of $2S$, $21^{\circ} 42' 14''$, to the Side TF the Excentricity required, viz. 56947.

The Operation.

Co Ar.

As the Sine of $11^{\circ} 30' 57''$ ————— 0.699755

Is to 11489 ————— Log. 4.060282

So is the Sine of $81^{\circ} 42' 14''$ ————— 9.995431

To 56947 ————— 4.755468

To find the Moon's Mean Anomaly, subtract the Place of the Apogee the second time equated, from the Place of the Moon equated the third time, and the Remainder will be the Mean Anomaly. Thus,

From 10 22 21 53

Subtract 8 06 24 11

Mean An. 2 15 57 42

In the next Place to find the fourth Equation of the Moon, I proceed thus: As the Sum of the Mean Distance of the Moon from the Earth, and of the present Excentricity, is to their Difference, or as SA (in Fig. 8.) equal to 1056947 is to PS equal to 943053; so (by Prop. 6. of Book the 3d of Gregory's Astronomy) is the Tangent of half the Mean Anomaly, to the Tangent of half the true Anomaly. This last subtracted from the 3d in the Proportion gives a Number, which being doubled, is the Prosthaphæresis required; to be subtracted, when the Mean Anomaly is less than 6 Signs, otherwise to be added to the 3d Equation, and the Remainder or the Sum will give the Place of the Moon equated a fourth time.

D 2

Opera-

*The Operation.*As 1098947 ~~Log~~ 3.975947To 943093 ~~Log~~ 5.974536So is the Tangent of $37^{\circ} 58' 51''$ — 9.892510To the Tangent of $34^{\circ} 51' 41''$ — 9.842993

From 37 58 51

Subtr. 34 51 41

Remains 3 07 10

Double 6 14 20

From 10 23 21 53

Subtr. 10 06 14 20

Leaves 10 16 07 33 for the Place

of the Moon the 4th Time equated.

For the 5th Equation, from this Place of the Moon subtract the true Place of the Sun, and lay, as Radius to the Sine of the double Distance of the Moon from the next Syzygia or Quadrature, so is the Number answering to the Logarithm in the Table of the Moon's Variation found by the Sun's Mean Anomaly, to the Number required; which if the Moon's Distance from the Sun be less than three Signs or between Six and Nine, must be added to; otherwise subtracted from the 4th Equation, and the Sum or Difference will give the Moon's Place equated a 5th time. For Example,

From 10 16 07 33

Subtr. 3 05 44 21

Remains 7 10 23 12

As Radius

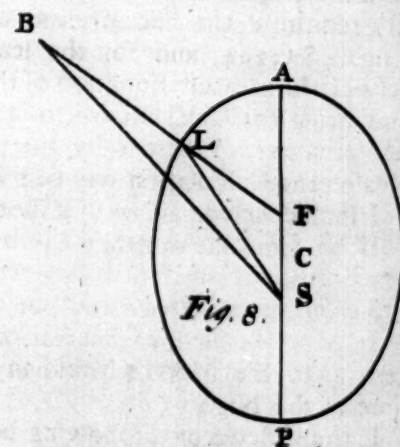
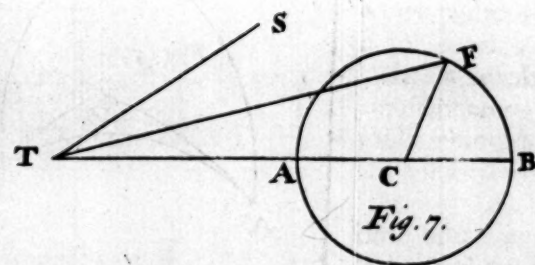
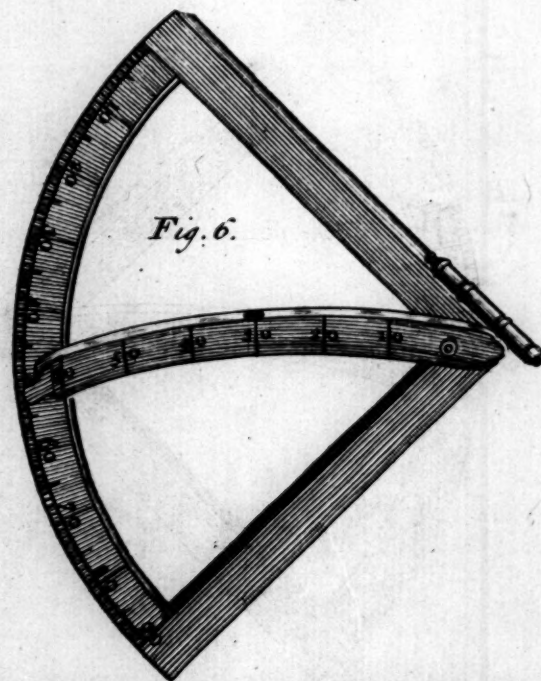
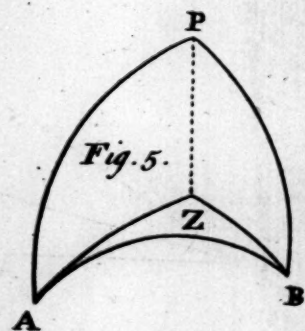
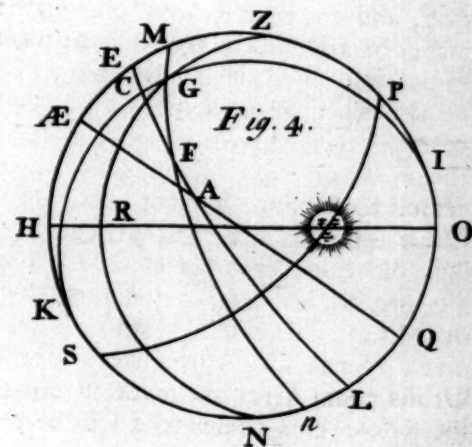
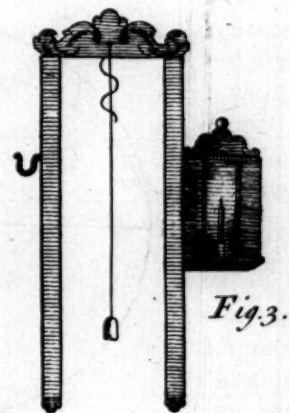
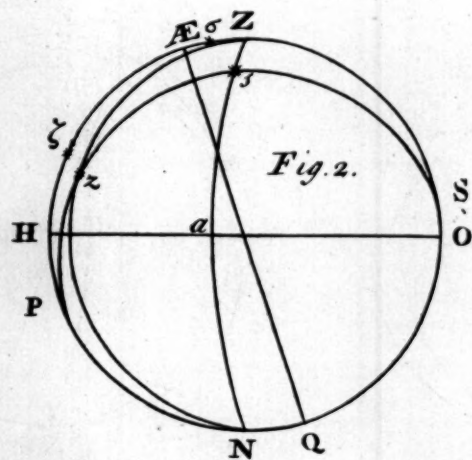
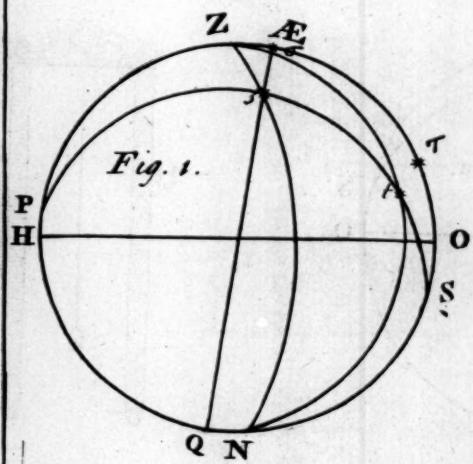
10.000000

To the S. of $86^{\circ} 46' 24''$ Log 9.994344So is $33^{\circ} 07'$ — 3.298388To $32^{\circ} 41'$ — 3.292733

If $32^{\circ} 41'$ be added to the 4th Equation, it will make 10 S. $10^{\circ} 40'$ for the 5th Equation.

Then from the Moon's Apogee the 1st time equated, subtract the Apogee of the Sun, and note the Remainder; likewise from the Place of the Moon the 5th time equated, subtract the Place of the Sun, and note the Remainder. Thus,

From



	S. ° ' "
To	10 16 39 53
Add	1 32
The 7th and last Equation	10 16 41 25

This is the Moon's Place in her Orbit, which yet is to be reduced to the Ecliptick. In order to which, from the Place of the Sun is to be subtracted the Place of the Node first equated, which was 6 S. 16° 33' 46", which subtracted from 3 S. 05° 44' 21", there remains 3 S. 19° 10' 35", in the Table of the Equation of the Node, the Number answering to this is —33 min. 58 sec. and the Inclination of the Limit 0 min. 38 sec.

	S. ° ' "
From	6 16 33 46
Subtract	33 58

Remains 6 15 59 48 this last is the true Place of the Node, and this being subtracted from the Place of the Moon in her Orbit, leaves 4 S. 00 deg. 41 min. 37 sec. For the Argument of Latitude; then in the Table of Reduction, the Number answering to this last is 5 min. 45 sec. to be added, and the Excess agreeing thereto being 43 sec. As 18 min. 00 sec. the greatest Inclination, is to 43 sec. 10 is 28 sec, 10 0 min. 01 sec. the proper Excess, this added to 5 min. 45 sec. makes 5 min. 46 sec. and this last added to the Moon's true Place in her Orbit

	S. ° ' "
	10 16 41 25
+	5 46
	10 16 47 11

Gives the Moon's true Place in the Ecliptick, or the true Longitude by Calculation.

This being finished, we are to enquire, whether the Observation will agree with it. In order whereunto it has appeared already, that at the time of Observation, the Moon's higher Limb was apparently distant from the Vertex 63 deg. 39 min. 30 sec. In the next Place the Horizontal Parallax must be found, which will be done by Fig. the 7th, For as the Sine of the Angle SLP, the Prosthaphæresis before found 6 deg.

6 deg. 14 min. 20 sec. is to the side SF, double the Excentricity equal to 113894, 10 is the Sine of LFS, or the Sine of the mean Anomaly A F L 2 S. 15 deg. 57 min. 42 sec. to the side S L, the Moon's Distance from the Earth.

Co. Ar.

As the Sine of $6^{\circ} 14' 20''$ ———— Log. 0.963874

Is to 113894 ———— 5.056501

So is the Sine of $75^{\circ} 57' 42''$ ———— 9.986831

To 1016731 ———— 6.007206

Then as this Distance is greater than the mean Distance 1000000; so is the Sine of the Horizontal Parallax of the Moon in the Syzygia (according to the Theory) 57 min. 30 sec. greater than the Sine of the present Parallax.

Co. Ar.

As 1016731 ———— Log. 3.991794

To 1000000 ———— 6.000000

So is the Sine of $57^{\circ} 30''$ ———— 8.223357To the Sine of $56^{\circ} 33'$ ———— 8.216151

The Parallax then being 56 min. 33 sec. in the Syzygia, the Horizontal Parallax proper for the Moon's present Distance from the Sun will be found to be 56 min. 13 sec. by this small Table framed from the Rules of the Theory.

The Use is thus; from the Moon's Place in her Orbit, subtract the Place of the Sun, and the nearest Distance from the Syzygia either forwards or backwards, look for in the Table, in the left Hand Column, or the nearest to it: then as $57^{\circ} 30''$ to the Number over-against it, so is the Horizontal Parallax before found, to the proper Parallax. Thus,

From ———— 10 16 41 25
Subtract ———— 3 05 44 21
Remains ———— 7 10 57 04

A TABLE whereby
to find the Moon's proper
Horizontal Parallax.

10	57	29
20	57	24
30	57	18
40	57	10
50	57	01
60	56	53
70	56	46
80	56	42
90	56	40

The

The Number in the Table answering nearest to $46^{\circ} 37' 04''$ is $57^{\circ} 09'$, therefore as $57^{\circ} 30'$ to $57^{\circ} 09'$, so is $56^{\circ} 33'$ to $56^{\circ} 13'$, the proper Parallax.

To find the Moon's apparent Diameter (according to the Theory)
As $57^{\circ} 30'$ to $31^{\circ} 30'$, so is $56^{\circ} 13'$ to $30' 48''$.

To the Vertical Distance of the Moon's higher Limb — $63^{\circ} 39' 30''$
Add the Apparent Semidiameter of the Moon — $15' 24''$

To this add the Refraction — $01' 40''$

Vertical Distance of the Moon's Center — $63^{\circ} 56' 34''$
Subtract the Parallax of Altitude — $30' 30''$

True Vertical Distance of the Moon's Center — $63^{\circ} 06' 04''$

As Radius — Log. 10.000000

To the Sine of the Vertical Distance $63^{\circ} 56' 34''$ — 9.953448

So is the Sine of $30' 13''$ — 8.213560

To the Parallax of Altitude $30' 30''$ — 8.367008

Altitude of the Moon's Center — $26^{\circ} 53' 56''$

Complement of the Latitude of Greenwich — $38^{\circ} 31' 30''$

Subtract the Altitude of the Moon's Center — $26^{\circ} 53' 56''$

Declination South of the Moon's Center — $11^{\circ} 37' 34''$

The Sun's true Place June 16th, at Noon — $3^{\circ} 5.09.08$

Right Ascension then — $95^{\circ} 36' 53''$

The Sun's true Place at Night — $3^{\circ} 05.44.21$

Right Ascension then — $96^{\circ} 15' 13''$

Difference of Right Ascensions — $38^{\circ} 20'$

95	02	02
96	02	02
97	02	02
98	02	02
99	02	02
00	02	02
01	02	02
02	02	02
03	02	02
04	02	02
05	02	02
06	02	02
07	02	02

Right

(333)

Right Ascension at Noon $9^{\circ} 36' 53''$
For 14 hours add $210^{\circ} 00' 00''$
For 46 Minutes add $11^{\circ} 30' 00''$
For 33 Seconds add $00^{\circ} 08' 15''$
For the Difference of Right Ascensions add $00^{\circ} 38' 20''$

Right Ascension of the Moon's Center $317^{\circ} 53' 28''$

By this and the Declination given South
the Longitude will be found, thus;

$108^{\circ} 37' 34''$	$108^{\circ} 37' 34''$
$+ 23^{\circ} 29' 00''$	$- 23^{\circ} 29' 00''$
$131^{\circ} 06' 34''$	$78^{\circ} 08' 34''$
$62^{\circ} 33' 17''$	$39^{\circ} 04' 17''$
Sum	Difference
half Sum	half Diff.

From $317^{\circ} 53' 28''$
Subtract $178^{\circ} 00' 00''$
Remains $47^{\circ} 53' 28''$ the contained Angle

$23^{\circ} 56' 44''$ the Half

Then First,

As the Sine of $62^{\circ} 33' 17''$	Co. Ar.
To the Sine of $39^{\circ} 04' 17''$	Log. 0.051855
So is the Co-tangent of $23^{\circ} 56' 44''$	9.799539
To the Tangent of $57^{\circ} 58' 59''$	10.352529
	10.203923

Again

Again,

Co. Ar.

As the Co-sine $62^{\circ} 33' 17''$ ————— Log. 0.336393
 To the Co-sine of $39^{\circ} 04' 17''$ ————— 9.890064
 So is the Co-tang. of $23^{\circ} 56' 44''$ ————— 10.352529
 To the Tang. of $75^{\circ} 13' 50''$ ————— 10.578985

To the Tangent of half $Z\sqrt{V}$ ————— 75 13 50
 Add the Tangent of half $X\sqrt{V}$ ————— 57 58 59

$316^{\circ} 47' 11''$ divided
 by 30 quotes
 res. $10^{\circ} 47' 11''$

Subtract — 133 12 49
 From — 180 00 00
 Remains — 46 47 11
 Add — 270 00 00
 Gives — 316 47 11

Exactly agreeing with the Calculation

Thus (may it please *Your Honours*) I have given *You* in full a Specimen of the Method of my Calculation in one Instance; and the rest upon Examination, will be found to be done with the same Care and Fidelity, which (though they do not agree so exact with the Observations, yet) are all of them near enough, and fall a great deal within the Limits prescribed by the Act, and may so plainly and fully be understood by what has gone before, that the Sailor may thereby be instructed to make the like Calculation upon any Observation, which was the chief thing I had in View, by this so full an Explanation. I am satisfied *Your Honours* will not suffer it to be turned to my Disadvantage. It may be thought by some, that this way of Calculation is too laborious, and will take up too much time; but if the Nature of the thing require it, I cannot help that. Yet if two Persons be employed upon every Occasion, one to manage the Observation, and the other the Calculation, 2 or 3 Hours in a Week, or perhaps in a Fortnight, should not (one would think) be grudged in so useful a Work. And this I know upon Experience to be sufficient; more especially, if the *Table of Logistical Logarithms* be added to the Book, as it is designed, that so it alone may serve all the Uses of Calculation where the Motions of the Moon are concerned.

At

At present to draw to a Conclusion, that I may trespass no longer upon *Your Honour's* Patience, be pleased to give me leave to make a short Recapitulation.

I have here presented *You* in the first Place, with several Methods of finding the Moon's Place by Observation, all of them Mathematically demonstrable, and all, or most of them easily and very often practicable. As they are all new to me, having never met with any one of them either by Reading or Conversation; but delivered them to the Publick as they occurred to me, upon a close and intense Application, so I hope they will appear to the Learned, especially to *Your Honour's*, and therefore will be the more taken Notice of.

I hope likewise, the Instrument here described, if truly made, and carefully applied, will easily and exactly answer the Ends of Observation, that is, by taking the true Altitude of the Luminaries, and making due Allowances for Parallax and Refraction, to find the Latitude and Hour to few Seconds, and thereby the exact Place of the Moon in her Orbit; which will be sufficient on the Observer's Part. And whilst he is Calculating the observed Place, another Assistant or Mate by consulting the *Tables*, and proceeding according to Sir *Isaac's* Method before given, will find at what time in the Meridian of *Greenwich* the Moon will be exactly or sufficiently near in the same Place; for in all the various Observations now to be exhibited, at the most different Seasons of the Year, and in all other Cases sufficiently different, the Moon's Place by the *Tables* agrees with the Observation within 10 or 15 Geographical Miles, excepting one, which exceeds ten; but that perhaps (as those two eminent Astronomers *Dr. Gregory* and *Mr. Whiston* justly suppose) may rather be imputed to the Uncertainty of Observation, than any Imperfection in the *Theory*. Now since the Moon's Mean Motion in 24 Hours is $13^{\circ} 10' 35''$ or 47435", that is in one Hour 1976", and 33" in one Minute of time, which answers to 15 Geographical Miles of the Earth's Equator, every two Seconds of the Moon's Motion will be but about one Mile in Longitude, even in the Earth's Equator, and as the Latitude increases still less and less, so that it may be said by this Method the Longitude may be found, sufficiently near; whereas by the Eccentricities in the printed *Theory*, viz. 66782 and 43319 the Moon's Place would in the 4th Observation (where it is now exact) be 6' 10" or 184 Miles too little, and in the 6th Observation 8' 46" or 263 Miles, by Reason those Eccentricities are too great, and therefore in the 4th Equation too much is subtracted. Likewise in the 3d Observation (which is here but 1 Second, or half

a Mile wide) it would be $4' 04''$, or 122 Miles too much: for the like Reason, because too much is added, and in none of these Observations would the *Longitude* be determined within 90 Miles.

I have only one thing more to add, which (though it be a new Notion, and for that Reason may perhaps not be so well relished, but rather be a Disadvantage to what has been before offer'd, yet) is proved to be undoubtedly true, by many of Mr. *Flamsteed's* Observations purposely examined, whereof the two last here produced, being taken so near together, do confirm the truth of one another, viz. that about the 19th or 20th of *December*, when the Earth is in the Perihelion and nearest to the Sun, and for about 6 Weeks before and after, the Moon's Orbit is not so much Excentrical, as when it is in the Aphelion or farthest off, but comes nearer to a Circle, and therefore the Excentricities are then still less than in the Summer, and this may be the Reason why the Moon's Periodical Motion is longer in the Winter than in the Summer; Since all Astronomers after *Kepler* agree, that in Elliptical Orbits equal Areas are made in equal times, and therefore the nearer the whole Area comes to a Circle, the greater will it be, and require a longer time; and accordingly in the Summer, when the Area is more Oblong and less, its Period is shorter; which agrees to truth, being one of the constantly observed *Phænomena* of the Moon's Motion. Whether this be true or no, (the truth of this is confirmed by *Prop. 17th Book the 4th, of Gregory's Astronomy*;) yet, since the Observations necessarily require it, the Excentricities are still less, viz. for the greatest 65057, Log. 4.813294, and for the least 42280, Log. 4.626137, these will answer the greatest Equation of the Moon's Apogee, viz. $12^{\circ} 15' 04''$, and bring the Calculations to agree exactly in one Example with the Observation: Whereas by the printed Excentricities, and for the same Reason the Calculation will be too little by $8' 46''$ or 263 Miles.

I shall conclude all with a short Argumentation.

If by some one or other of the foregoing Methods, being carefully practiced by a sufficient Instrument, the Moon's Place may be found by Observation, as often as will be necessary.

If Mr. *Flamsteed's* Observations now to be produced, are truly taken, as to the Moon's Meridian Altitude, and the apparent or true time of the Night.

If the Calculations following be found upon Examination, to be truly and faithfully performed according to the Rules of the *Theory*, as now freed from the Errors of the Press.

And

And lastly, if by this necessary Correction, and no other, the Moon's Place may be found by *Tables* made exactly agreeable to the *Theory*, (as so altered and corrected) within five, or very few Miles of Truth.

Then one should be inclined to think this Consequence would justly follow; that by the late incomparable and admirable Sir *Isaac Newton's Theory* of the Moon, assisted by *Tables* exactly agreeable thereunto, may sufficiently be found the *Longitude* at Sea.

But the Antecedents 'tis presumed will appear to be all true.

And therefore — I leave it to *Your Honours* to infer the Conclusion; in Confidence of whose most exact Judgment and impartial Determination, I beg leave with the utmost Submission and Respect, to subscribe my self

YOUR HONOURS

most obedient,

and most humble Servant,

From *Warrwick* in
Lancashire, the
21st of *August*,
A. D. 1727.

Robert Wright.

A. D.

A. D. 1692, March 18 day 08h. 54m. 48s. ☉s Apogee 3S. 7d. 35m. 16s. ☉s Mean Anomaly 8S. 29d 34m 54s. Eq. Orbit +1d. 56m. 20s. Eq. of time +4m. 41s. ☉s true Place 0S. 09d. 06m. 42s.

A. D. 1692, March 18 day 08h. 59m. 29s. Mean Time.

☉s Equ.	☉s Mean Motion	☉s Apogee	☉ Ascend. Node
	S. ° ' "	S. ° ' "	S. ° ' "
	4 23 52 26 — 11 49	11 10 43 36 + 20 00	10 17 22 18 — 09 30
1 st Equa.	4 23 40 37 — 03 06	11 11 03 36 + 08 57 01	10 17 12 48 — 01 27 37
2 ^d Equa.	4 23 37 31 — 46	11 20 00 37 Excent. 61297	10 15 45 11 Inc. Limit 6 51
3 ^d Equa.	4 23 38 17 — 03 18 02	☉s mean Anamoly 5 03 37 40	Vert. Dist Moons higher Limb.
4 th Equ.	4 20 20 15 — 35 15	Mar. 18 day Noon S. ° ' "	37.00 55 Error div. + 0.02
5 th Equ.	4 19 45 00 — 51	☉ pla. 0.08.44 44 R. Asc. 08.01.52 At Night ☉s pla. 0.09 06.42	Error Wall — 2.50 Semid. ☉ + 16.30 Refract. + 0.36 Vert. dist. ☉ Cent. 37.15.13
6 th Equ.	4 19 44 09 — 01 46	R. Asc. 08.22 05 Diff. R. Af. 20 13 R. A. Moons Cent.	Par. Af. — 36.29 True Vert. Dist. Moon's Center 36.38 44
7 th Equ.	4 19 42 23 Reduct — 57	142.04.05 Hor. Par. Syz. 60.48 Pro. Ho. Par. 60.16 Appar. Diam. of the Moon 33' 01"	Al. ☉ Cen. 53.21.16 Com. Lat. Greenw. — 38.31.30 Dec. No. ☉ Cent. 14.49.46
Long. Cal.	4 19 41 26		
Lon. Obs.	4 19 40 59		
Diff. Long.	0 27		
13 $\frac{1}{2}$ Miles.			

A. D. 1714

The Second Observation,

39

A. D. 1714, September 10 day 10h. 17m. 33f. ☉'s Apogee 3S. 7d. 58m. 53f. ☉'s Mean Anomaly 2S. 22d. 23m. 52f. Eq. Orbit — 1d. 54m. 52f. Eq. Time — 7m. 03f. ☉ true Place 5S. 28d. 27m. 16f.

A. D. 1714, September 10 day 10h. 10m. 30f. Mean Time

☉'s Eq.	☉'s Mean Motion	☉'s Apogee	☉ Ascend. Node
	S. ° ' "	S. ° ' "	S. ° ' "
	11 05 54 10	05 25 30 21	08 02 33 17
	+ 11 40	— 19 44	+ 09 22
1 Equa.	11 06 05 50	05 25 10 37	08 02 42 39
	— 25	+ 01 08 48	+ 01 11 19
2 Equa.	11 06 05 25	05 26 19 25	08 03 53 58
	— 37	Excent. 65540	Incl. Limit 3 24
3 Equa.	11 06 04 48	☉'s Mean Anom.	Ver. dist. ☉ lower
	— 02 46 06	05 09 45 23	Limb 58° 31' 10"
4 Equa.	11 03 18 42	Sept. 10 day Noon	Error Div. 10 42
	— 27 12	☉ pla. 5.28.02.02	Er. Wall — 14 10
		R. Asc 178.11.48	Semid. ☉ — 16 43
5 Equa.	11 02 51 30	At Night	Refract. + 1 17
	+ 01 4	☉ pla. 5.28.27.16	Vertical dist. ☉'s
		R. Asc 178.34.57	Center 58 02 16
6 Equa.	11 02 53 12	Dis. R. Asc .23.09	Par. Alt. — 51 49
	— 01 08	R. Asc ☉ Center	True Ver. dist. ☉'s
		232.58.12	Center 57 10 27
7 Equa.	11 02 52 05	Hor. Par Syz 61.14	Alt. of ☉'s Cent.
	Reduct — 14	Pro Hor Par 61.04	32 49 33
		Ap Dia ☉ 33.27	Comp. Latitude
Long. Cal. 11 02 51 51		Par. Altitude	Greenwich.
Long. Obs. 11 02 51 42		51.49	38 31 30
Diff. Long. 09			Decl. S ☉'s Cent.
or 4 Miles			5 41 57

A. D. 1691

The Third Observation.

A. D. 1691, September 20 day 07h. 11m. 26l. ☉'s Apogee 3 S. 7d. 34m. 45l. ☉'s Mean Anomaly 3 S. 1d. 6m. 37l. Eq. Obliq. — 1d. 56m. 20l. Eq. time — 10' 12" ☉'s true Place 6 S. 07° 44' 37".

A. D. 1691, September 20 day 07h. 11' 14" Mean Time

☉'s Eq.	☉'s Mean Motion	Moon's Apogee	☉ Ascend. Node
	S. ° ' "	S. ° ' "	S. ° ' "
	9 21 07 44	10 20 39 53	10 26 54 28
	+ 11 49	— 20 00	+ 9 30
1 Equa.	9 21 19 33	10 20 19 53	10 27 03 58
	— 3 43	+ 12 08 59	— 1 28 15
2 Equa.	9 21 15 50	11 03 28 52	10 25 35 43
	+ 46	Excent. 54395	Incl. Lim. 10 20
3 Equa.	9 21 16 36	☉'s Mean Anom.	Ver. dist. ☉'s slow.
	+ 3 56 36	10 18 47 44	Limb 76° 33' 15"
4 Equa.	9 25 13 13	Sept. 20 day Noon	Er Div. — 00 04
	— 10 23	☉'s Place 6 S. 07° 26' 29"	Er. Wall — 02 20
5 Equa.	9 24 52 49	R. Asc. 186.49.52	Semid. ☉ — 14 51
	+ 40	☉'s Pla. at Night	Refract. + 03 17
6 Equa.	9 24 53 29	6 07 44 37	Vertical dist. ☉'s
	— 2 14	R. A. 187 06 33	Center 76 19 17
7 Equa.	9 24 51 15	Diff. R. A. 16 41	Par. Alt. — 52 41
	Reduct + 6 20	R. A. ☉'s Center	True Vert. Dist.
Lon. Cal. 9 24 57 31		297 28 03	☉ Cen 75 26 36
Lon. Obs. 9 24 57 36		Hor. Par. Syz. 54 56	Altit. ☉'s Center
Diff. Long	01	Pro. Ho. Par. 54.13	14 33 24
or half a Mile		Ap. Dia. ☉ 29 42	Compl. Latitude
		Par. Altit. 52 41	Greenwich
			38 31 30
			— 14 33 24
			Decl. S. ☉'s Cent.
			23 58 05

A. D. 1698

The Fourth Observation.

47

A. D. 1698, June 16th day, 14h. 48' 53". S. Apogee 3 S. 7d.
4m. 50f. S's Mean Anomaly 13. 7d. 50m. 23f. Eq. Orbit +
4m. 00f. Eq. time + 6s. 20f. S's true Place 3 S. 65° 44' 21".

A. D. 1698, June 16 day, 14h. 48' 53" Mean Time

S's Eq.	S's Mean	Motion	Moon's Apogee	S's Ascend. Node
S. 2 10 22 + 24	S. 2 10 22 25 32 - 24	1 1 7 24 53 33 41	S. 2 10 22 7 24 53 33 41	S. 2 10 22 16 26 34 06 — 20
1 Equa.	10 22 - 1	25 68 3 32	7 24 + 11 30 57	16 26 + 33 58
2 Equa.	10 22 - 1	25 36 + 17	8 06 Excent. 56947	16 25 Incl. Lim. 0 38
3 Equa.	10 22 - 6	21 53 14 20	S's Mean Anom. 2 15 57 42	Ver. dist. 2's high. Limb 63° 46' 40"
4 Equa.	10 16 - 1	07 23 32 42	Year today Noon S's Pla. 2. 05. 09. 08	Er Div. + 00 20
5 Equa.	10 16 - 1	40 13 32	R. A. 95. 36. 53 S's Pla. at Night	Er. Wall + 07 30
6 Equa.	10 16 + 1	32 53 1 32	3. 05. 44. 27 R. A. 96 15 13	Semid. + 15 24
7 Equa.	10 16 + 1	41 25 5 46	Diff. R. A. 38 20 R. A. S's Center	Refract. + 01 40
Lon. Cal 10 16 Lon. Ob. 10 16 Diff. Long.	47 11 47 11 00	Hor. Par. Syz 36 13 Pro. Ho. Par 56. 13 Ap. Dia. 30 48 Par. Alt. 56 13	Center 63 56 34 Par. Alt. - 50 30 True Vert. Dist. Cen 63 06 04 Compt. Latitude Greenwich 38 31 30 Decl. S. S's Cent. 17 37 34	

F

A. D. 1691

A. D. 1691, December 18 day 06h. 37m. 00s. ☉'s Apogee 3S. 7d. 35m. 01s. ☉'s Mean Anomaly 5S. 29d. 47m. 28s. Eq. Orbit — 26s. Eq. Time + 2m. 36s. ☉ true Place 9S. 07d. 33m. 10s.

A. D. 1691, December 18 day 06h. 39m. 36s. Mean Time.

☉'s Eq.	☉'s Mean Motion	☉'s Apogee	☉ Ascend Node
S. 0 33	16 50	S. 0 34 36	S. 0 10 22 11 46
05 —	15 3	11 00 34 36	10 22 11 46
1 Equa.	00 23	11 00 34 36	10 22 11 48
82 28	— +	11 13 13 05	+ 1 29 38
2 Equa.	00 33	10 18 21 27	10 22 41 26
88 0	— 47	Excent. 5 16 18	Incl. Limit 9 03
3 Equa.	00 33	11's Mean Anom.	Ver. dist. > lower
00 05	14 58	2 05 08 26	Limb 41° 17' 10"
4 Equa.	00 18	Dec. 18 day Noon	Error Div. + 30
42 21	82 53	☉ pla. 9.07.05.42	Er. Wall — 2 30
5 Equa.	00 18	R. Alc. 277.43.42	Semid. > — 15 10
48 07	01 21	☉ pla. at Night	Refract. + 42
6 Equa.	00 18	9 07 23 10	Vertical dist. >'s
42 00	02 23	R. Af 378 02 39	Center 41 00 32
42 00	02 17	Dif. R. Af 18 17	Par. Alt. — 26 30
7 Equa.	00 18	R. Alc > Center	True Ver. dist. >'s
08 22	00 06	14 47 39	Center 40 24 12
Reduct	— 6 36	Non-Par. Syz. 56.09	Alt. of >'s Cent.
Long. Cal.	10 17 53 39	Pro-Hor. Par 55.22	49 35 48
Long. Qbl.	0 17 53 38	Ap-Dia > 30 20	Comp. Latitude
Diff. Long.	08	Par. Altitude	Greenwich.
or 4 Miles		36.20	— 38 31 30
			Decl. N >'s Cent.
			11 04 18
			Long. 17 53 38

43

A. D. 1691, Decem. 19 day 07h. 13m. 42s. Mean Time.

1 st Equat.	2 nd Mean Motion	3 rd Apogee	4 th Ascend. Node
S. 0 1 37	S. 0 1 37	S. 0 1 37	S. 0 1 37
1 st Equat.	1 07 01 37	11 00 41 30	10 22 08 29
	+ 03 48	14 28	+ 01 29 26
2 nd Equat.	1 07 05 15	10 28 27 19	10 23 37 47
	47	Excent. 51987	Inc. Limb 9 23
3 rd Equat.	1 07 04 38	Es mean Anomaly	Vert. Dist. Moons
	- 05 46 34	2 18 37 09	lower Limb.
4 th Equat.	1 01 17 54	Dec 19 day Noon	Error div. 35 58 40
	26 47	S. 0 1 37	Error Wall. 3 10
5 th Equat.	1 00 51 07	© pla. 9 08 06 74	Semid. 24 15 21
	+ 58	R. Asc. 278.50.13	Refract. + 35
6 th Equat.	1 00 52 05	©s pla. At Night	Vert. dist. 2 Cent.
	03 09	9 08.25.12	35 41 39
		R. Asc. 279.11.25	Par. Alt. 32 41
		Dist. R. A. 21.13	True Vert. Dist.
		R. A. Moons Cent.	Moon's Center
7 th Equat.	1 00 49 56	26 50 25	35 08 58
	Reduct - 5 00	Hor. Par. Syz. 56 42	Alt. 54 51 03
		Pro. Ho. Par. 56 00	- 38 31 30
Long. Cal.	2 00 44 56	Appar. Diam. of	Dec. No. 2 Cent.
Long. Obs.	1 00 44 56	the Moon 30 43	10 19 32
Diff. Long.	1 00 44 56		Long. 1.00.44.56

A CATALOGUE of those Stars whose Right Ascension is nearly the same.

Stars Names	Right Asc	Dist from the North Pole	Varia of R.A.	Variation of the Po lar Dist	Magni
	d m s	d m s	m s	d m	
Northern in the Fins of the Whale's Tail marked (D)	01 21 30	100 24 93	54 59	-23 54	03
In the middle of Toucan's Wing	01 13 39	23 35 39	63 27	23 10	03
Former before Whale's Tail (n)	13 42 27	101 38 56	55 54	-23 18	03
South in Andromeda's Girdle (P)	13 54 35	055 51 00	98 30	-23 00	03
In Perseus's Scymitar (Q)	21 45 02	40 41 59	64 43	-21 22	04
In Eridanus, Achernar (R)	21 45 08	31 28 50	60 28	22 09	01
In the Knot of the two lines of Pisces (a)	26 58 22	88 34 25	55 14	-21 30	03
Above Andromeda's Left Foot (d)	26 49 29	49 02 18	68 57	-21 33	2.3
In the Whale's Jaw (e)	26 58 22	88 34 25	55 14	-21 30	03
Before Medusa's Head (f)	26 58 22	88 34 25	55 14	-21 30	03
In the tip of the Bull's So phom (Z)	26 58 22	88 34 25	55 14	-21 30	03
Middle of the Bull's Body (d)	26 58 22	88 34 25	55 14	-21 30	03
Brown Right Shoulder	26 58 22	88 34 25	55 14	-21 30	03
East of the Bright Star in the Deer	26 58 22	88 34 25	55 14	-21 30	03
Pollux (g)	26 58 22	88 34 25	55 14	-21 30	03
Middle of Argo's Scutum	26 58 22	88 34 25	55 14	-21 30	03

Star's Name	Right Asc.	Distance from the North Pole	Variat. of R. Alc.	Vari. of Polar Distan.	Magni- tude
1 m 1 m 1	d m f	d m f	m f	m f	
Hydra's Heart	138 31 21	97 29 15	52 57	17 40	3.2
+ North part of the Section of Argo's Keel	138 22 22	36 11 39	33 22	17 57	3.2
Hydra's Heart	138 31 21	97 29 15	52 57	17 40	3.2
Great Bear's left Knee (φ)	138 37 21	37 05 27	76 41	17 34	3.4
In the Great Bear's Ribs (α)	161 38 05	26 46 06	71 30	22 32	4
Bottom of the Bowl (α)	161 38 20	106 50 30	52 40	22 31	4
+ Northern in the Centaur's Right Thigh (β)	178 35 38	40 49 54	54 33	23 04	3
Raven's Bill (α)	178 34 50	113 12 07	54 39	23 54	4
Raven's Right Wing (γ)	180 26 56	108 01 07	54 50	23 53	3
+ First in the Crofers (γ)	180 15 33	32 47 45	55 30	23 54	5
Virgin's Spike	197 41 04	99 43 27	16 08	22 47	3
Mid. of Great Bear's Tail (ε)	197 44 03	33 37 44	44 05	22 47	3
+ Star after the left Knee of the Centaur	215 12 28	26 12 12	89 37	19 21	3
Bootes's Left Shoulder (γ)	215 14 53	30 29 15	43 45	19 45	3
In the Serpens Neck (δ)	230 26 07	78 32 06	51 44	15 32	3
In the Little Bear (γ)	230 21 17	17 11 57	05 26	15 13	3
Serpens (α)	232 41 32	82 41 43	52 33	14 46	2
+ North Basis of Sou. Triangle	232 55 11	27 28 47	92 16	14 30	3
Scorpio's Heart, Antares (α)	243 10 04	115 47 31	65 08	11 10	1
Next after Hercules's Right Knee	243 08 06	57 00 22	41 11	11 04	5
Scorpio (ε)	248 07 20	123 45 26	69 39	09 22	3
Hercules (α)	248 20 52	50 32 12	36 44	09 04	3

Above

Star's Name	Right Asc.	Distance from the North Pole	Variat. of R. Alc.	Variat. of Polar Distanc.	Magni- tude.
Above Dragon's Eye (α)	261 08 46	17 28 46	24 24	03 52	2.3
In the Head of Serpenter (α)	260 32 36	17 13 24	49 14	04 17	2.2
Draco (γ)	267 35 29	38 27 43	14 57	01 10	2
Sagittar. (γ)	267 02 36	120 23 27	19 02	01 43	3
Hercules (A)	270 21 14	58 38 25	40 28	00 09	4.5
Sagittar. (δ)	270 50 39	119 34 18	68 48	00 03	3
In the Serpent's Tail (α)	271 47 48	92 56 28	56 16	00 24	3
In the South part of Sagittar's Bow (α)	271 29 59	124 18 40	71 28	00 10	3
Cygnus (δ)	294 04 48	45 30 59	33 35	09 31	3.4
Aquila (α)	294 19 56	81 50 10	31 21	09 36	1.2
Cepheus (α)	339 56 12	25 14 04	37 23	21 22	4
Aquar. (δ)	340 02 22	107 16 21	57 44	22 19	3
Calliope's Chair (A)	358 40 47	32 21 22	35 57	23 12	3.1
Head of Andromeda (α)	358 33 21	62 25 49	54 47	23 33	2

A *CATALOGUE* of some other Stars of the First and Second Magnitude not mentioned before, with their *Right Ascensions*, &c. which may be of Use in finding the *Latitude* and *Hour* of the Night.

Stars Names.	Right Asc.	Dist. N. P.	Var. R. A.	Var. P. d. M.
	d. m. s.	d. m. s.	m. s.	d. m.
+ Bright Star in the Head of the Phoenix }	3 06 17	46 12 37	53 38	22 53 02
Pole Star —————	9 38 14	01 09 33	161 28	23 33 04
Bright Star <i>Aries</i> —————	27 36 11	67 51 05	39 22	21 20 11
New* in the <i>Whales</i> Breast (o) —	31 22 31	94 14 17	34 02	20 36 02
Medusa's head, <i>Argol</i> (β) ———	42 36 18	50 07 52	68 06	17 56 03
Perseus Right side <i>Algenib</i> (α) —	46 14 06	41 08 28	74 11	16 54 02
In Eridanus (γ) —————	56 18 57	104 18 19	49 54	13 32 02
Bull's Eye, <i>Aldebaran</i> (α) ———	65 02 54	74 04 26	61 07	10 28 01
Capella (α) —————	74 07 10	44 18 31	78 20	07 07 01
Bright Star in Orion's left Foot, <i>Rigel</i> (β) —————	75 20 45	98 32 48	51 31	06 25 01
First in Orion's Girdle (α) ———	79 29 34	90 32 02	54 48	04 45 02
Great Dog's Fore Foot (β) ———	92 40 10	107 49 34	47 15	03 47 02
+ Canopus, or the Ship's Stern (α) —————	94 30 44	37 28 04	23 58	01 53 01
Pollux Left Foot (γ) —————	95 27 45	73 24 10	62 10	01 50 02
Great Dogs Mouth <i>Syrus</i> , (α) —	98 16 33	106 20 48	48 07	03 07 01
Castor (α) —————	109 15 46	57 32 38	69 31	07 26 01
Procyon (α) —————	111 14 03	84 05 24	57 25	08 17 01
+ Root of the Royal Oak ———	137 25 37	21 27 07	13 39	17 38 02
Lyon's Heart <i>Regulus</i> (α) ———	148 26 04	76 42 49	58 08	20 08 01
Lyon's Tail, <i>Deneb</i> (β) ———	173 46 06	73 54 17	55 51	23 43 01
+ Southern in the Crossiers (ζ) —	182 57 34	28 27 04	57 40	23 52 02
+ The Northern (ε) —————	184 05 54	34 27 11	57 52	23 49 02
Great Bears Rump, <i>Eliot</i> (ε) —	190 30 49	32 21 56	48 38	23 33 02
Arcturus —————	210 47 43	69 21 21	50 26	20 43 01
+ Right Foot of Centaur (α) ———	215 25 35	30 20 07	79 14	19 18 01
The South Ballance —————	218 57 36	104 53 00	58 52	18 51 02

Star Names.	Right Asc.	Dist. N. P.	Var. R. A.	Var. P. d.	Mag.
	d. m. s.	d. m. s.	m. s.	m. s.	
The North Ballance.	223 55 13	98 21 16	37 24	17 03	02
The Northern Crown (α)	230 46 41	62 20 59	45 21	15 18	02
Northern of the 3 in the Scorpion's Forehead, (α)	237 24 25	109 01 46	61 49	13 12	02
+ The Vertex of the Sou- thern Triangle	244 56 20	21 33 48	110 28	—09 47	02
Lyra (α)	276 34 04	51 27 06	36 08	—02 37	01
+ Peacock's Eye	300 57 03	32 27 47	86 55	12 29	02
Swan's Tail (α)	307 58 50	45 40 45	36 39	—14 30	02
+ Crane's Tail	336 26 23	41 41 25	65 26	—23 00	02
Pomalhaut	340 35 04	121 03 33	60 07	—22 24	01
In Pegasus Scheat (β)	342 37 06	63 24 18	51 22	—22 43	02
Marchab (α)	344 46 03	76 16 23	53 16	—22 43	02
End of Pegasus's Wing	359 46 58	76 20 58	54 56	—23 58	02

The Reader is desired to correct these few Mistakes.

Page	Line	Read.	Page	Line	Read
7	10	Sc.	44	19	for ' read >
8	16	Lanthorn	45	15	
14	9	reasonable		21	
15	1	Complement	46	7,8	
16	31	towards you. At	47	14	(θ) Sirius
18	23	Edition.		23	
29	22	2' 20"	45	9	
41	15	—7' 30"	47	24	
44	18	63' 57"			

20	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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These two Catalogues I should hope would be much valued; since they are no where else to be met with, but in the Original, viz. Mr. Flamsteed's *Historia Caeli Britannici*, from whence they are taken, and calculated to the Beginning of the Year 1726, according to his Rules of Variation, which it will be very proper and necessary here to set down, otherwise even these Catalogues will be of Use but for a short time.

The Reason of this Variation is, that the Equinoctial Points are found to recede 50" in a Year, and that thereby the Longitude of a Star, or its Distance from those points will be increased 1 Degree in 72 Years; and the Longitude being increased, the Right Ascension will be so too, and the Polar Distance also changed. Therefore if you would know the true Right Ascension and Declination of a Star any time to come, work thus, As 72 to the Interval of Years, so is the Number in the Table, to the Proportional Parts, to be added in the Right Ascension, (except in some few Stars near the North Pole, as the Star in the *Little Bear* (γ) whose Variation must be subtracted) and in the Polar Distance too, if the Stars Longitude be in any of the Signs from the Beginning of *Cancer*, to the Beginning of *Capricorn*; but if the contrary, to be subtracted from the North Polar Distance found in the Table.

For Instance, if you would know the Right Ascension and Declination of *Achernar*, the First of July in the Year 1740: From the Beginning of 1726 to that of 1740 are 14 Years, therefore by the Rule of Proportion, As 72 : 14 $\frac{1}{2}$:: 40m. 28s. : 8m. 09s. the Right Ascension of *Achernar* will then be 21 deg. 53 min. 17 sec. so for the Declination, As 72 : 14 $\frac{1}{2}$:: 22m. 09s. : 4m. 27s. which 4' 27" ought to be subtracted from the Polar Distance, because the Star is in *Pisces*, but here the Distance being from the South Pole it must be added, therefore to 31 deg. 21 min 50 sec. add 4 min. 27 sec. the Sum 31 deg. 26 min. 17 sec. will be the South Polar Distance of *Achernar* at that time, and its Complement 58 deg. 33 min. 43 sec. will be it's Declination South, and thus of the rest.

After this Manner, by a very easy Computation must the true Right Ascension and Declination of every Star be found, whenever an Observation is taken, otherwise the Calculation will not be exactly true. To know when the Proportional Parts are to be added and when subtracted, this Mark (—) prefixed to the Polar Distance, shews they must be subtracted, when there is no Mark they must be added; this Mark (+) set before a Star's Name, means that it's Distance is taken

from the South Pole; if no Mark, it is taken from the North, and so much may suffice for a full Explanation of the Catalogue.

I have now but one Observation or two to make, before I conclude. The learned Mr. *Whiston* in his *Astronomical Lectures*, is pleased to banish the Motion of the Sun's Apogee, or the Earth's Aphelion out of the Heaven's; but since Sir *Isaac* allows it a slow Motion, viz. 4' 20" in 30 Years, and since Dr. *Gregory* is of the same Judgment, as appears from *Proposition* the 15th of his 3d *Book*, and likewise from *Schol. Proposition* the 20th, *Book* the 4th, therefore he will please to excuse me, if in my *Tables* I differ from him in this Particular. Lastly, as to the Advantage of the foregoing Methods above others, it may be observed, that whereas the Eclipses of the Sun and Moon happen too seldom to be of much Use, and the Eclipses of *Jupiter's* Satellites cannot be discovered without long Telescopes; and whereas the Method by the Occultation of the Fixed Stars is very difficult and uncertain, by Reason of the Moon's Parallax, though made easier by Mr. *Flamsteed's Geometrical Construction*; this of the Moon her self is a constant and never failing Phenomenon, only for two or three Days before and after the Change, so that all the rest of the Month, there is never wanting (in proper Weather) either Night or Day a fit Opportunity of discovering the *Longitude*, therefore 'tis to be hoped, it will be accepted by the learned World, especially by the Honourable and Learned Commissioners.

F I N I S.

